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Geology, Development History, and Exploration Alternatives for Gypsum Resources at Cape Maringouin (Parts of NTS 21 H/10, 21 H/15 and 21 H/16), Westmorland County, Southeastern New Brunswick

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Minister of Natural Resources and Energy

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Frontispiece: The remnants of a wharf with exposures of gypsum in the background on the west coast of the Cape Maringouin Peninsula, southeastern New Brunswick. During the early part of the twentieth century the New Brunswick Gypsum Company extracted several hundred tons of gypsum annually from a small quarry nearby, shipping it in bulk from this wharf to plaster mills in the United States. The Cape Maringouin site was abandoned for economic reasons around 1921 and has been dormant ever since.

ABSTRACT

Near surface deposits of calcium sulphate in the west-central half of the Cape Maringouin Peninsula of southeastern New Brunswick represent a blend of bedded primary anhydrite ($CaSO_4$), primary and secondary bedded to massive gypsum [hydrated anhydrite ($CaSO_4 \cdot 2H_2O$)]; and limited quantities of recrystallized gypsum.

The gypsum resource in the Cape Maringouin Peninsula has had a limited production history. The most prominent and prolonged period of mining activity began in the early 1900's and continued for almost 20 years when small cargoes of "crude rock" were exported by boat to plaster mills along the northeastern seaboard of the United States.

The sulphate rocks belong to Lower Carboniferous Lime-kiln Brook Formation, a sequence of marine carbonates, and evaporites interstratified with nonmarine clastic sedimentary rocks. Recent reconnaissance work in the area suggests the probability of at least two separate sulphate units associated with the Lime-kiln Brook strata. The problematic spatial distribution of gypsum in the area is linked to primary and secondary depositional processes and subsequent structural controls.

Primary deposits appear to be of limited thickness, often interstratified with clastic sedimentary rocks and carbonates, which tend to impact negatively on the quality and consistency of the resource.

Secondary gypsum deposits in the area appear to be more extensive and of considerable interest from a resource development perspective. The distribution of this gypsum resource is linked directly to the structural development of the region and to a series of faults related to the upward movement of a salt-cored piercement structure, forming the Maringouin Anticline. Overlying and peripheral faulted terrain associated with this structure provides suitable hydration zones for the alteration of primary bedded anhydrite to massive gypsum accompanied by subsequent episodes of recrystallization. Fault structures also play a significant role in the spatial distribution of sulphate resources by influencing local dissolution of underlying evaporites and the subsequent collapse and deformation of cover rocks.

Considering an exploration model that links the spatial distribution of gypsum in the Cape Maringouin area to faulted terrain, there appears to be a few untested sites south and east of the former workings that may yield small deposits of relatively high quality material. With its remote location and the potential for land use conflict minimized, the Maringouin gypsum prospect has appeal as an exploration and potential development alternative.

RÉSUMÉ

Les gîtes subaffleurants de sulfate de calcium dans la moitié du centre-ouest de la péninsule de Cap Maringouin dans le Sud-Est du Nouveau-Brunswick représentent un mélange d'anhydrite primaire litée ($CaSO_4$), de gypse primaire et secondaire lité à massif [anhydrite hydratée ($CaSO_4 \cdot 2H_2O$)] et de quantités restreintes de gypse recristallisé.

Les ressources en gypse de la péninsule de Cap Maringouin ont fait l'objet d'une production limitée par le passé. La période la plus importante et prolongée d'activité minière a débuté au commencement des années 1900 et a duré près de 20 ans. On exportait alors de petites cargaisons de « pierre brute » par bateau vers des fabriques de plâtre longeant le littoral du Nord-Est des États-Unis.

Les roches de sulfate font partie de la Formation du Carbonifère inférieur de Lime-kiln Brook, une séquence de carbonates marins et d'évaporites interstratifiées de roches sédimentaires clastiques non marines. De récents travaux de reconnaissance dans le secteur permettent de supposer la probabilité d'au moins deux unités distinctes de sulfate associées aux strates de Lime-kiln Brook. La répartition spatiale problématique du gypse dans le secteur est liée aux processus de sédimentation primaire et secondaire et aux contrôles structuraux subséquents.

Les gîtes primaires semblent avoir une épaisseur limitée; ils sont souvent interstratifiés de roches sédimentaires clastiques et de carbonates, qui affectent en général négativement la qualité et l'uniformité des ressources.

Les dépôts secondaires de gypse dans le secteur semblent plus étendus et ils présentent un intérêt considérable du point de vue de la mise en valeur des ressources. La distribution de ces ressources de gypse est directement liée au développement structural de la région et à une série de failles apparentées au mouvement ascendant d'une structure diapirique à noyau salé formant le pli anticlinal Maringouin. Le terrain faillé sus-jacent et périphérique associé à cette structure procure des zones d'hydratation propices à une altération de l'anhydrite litée primaire variant au gypse massif accompagnée d'épisodes subséquents de recristallisation. Les structures faillées jouent elles aussi un rôle déterminant dans la distribution spatiale des ressources de sulfate en influant sur la dissolution locale des évaporites sous-jacentes et sur la déformation et l'effondrement subséquent des roches de couverture.

Compte tenu d'un modèle d'exploration reliant la distribution spatiale du gypse dans le secteur de Cap Maringouin au terrain faillé, il semble subsister quelques emplacements intouchés au sud et à l'est des anciens chantiers qui pourraient abriter de petits gîtes de matériau de qualité relativement élevée. Vu son emplacement éloigné et les possibilités minimes de conflits d'utilisation des terres, la zone productive possible de gypse de Maringouin s'avère attrayante comme secteur d'exploration et d'exploitation éventuelle de rechange.

Geology, Development History, and Exploration Alternatives for Gypsum at Cape Maringouin, (Parts of NTS 21 H/10, 21 H/15 and 21H/16), Westmorland County, Southeastern New Brunswick

Introduction:

General location: Calcium sulphate deposits of gypsum and anhydrite occupy the central portion of the Cape Maringouin Peninsula, the southernmost part of Westmorland County in southeastern New Brunswick. Maringouin is 16 km south of the Village of Dorchester and 18 km south of the Town of Sackville (Figure 1). It is within 50 km of Moncton, New Brunswick's second largest city.

Near surface deposits of gypsum and anhydrite underlie a 120-hectare site between the Shepody Bay coastline and Pink Rock Lake in the west-central half of the peninsula. Determining the nature and character sulphate resource in the area is limited to the examination exposures on the coast adjacent Shepody Bay and a few isolated outcrops in the vicinity of Pink Rock Lake (Figure 1). Coastal exposures are accessible south of a sharp bend in the Johnson Mills-Dorchester roadway. At this point one must proceed 2 to 3 km south either by walking along the beach (*i.e.* the Maringouin Flats) at low tide or by a trail adjacent the coastline. This trail also leads to Pink Rock Lake.

General physical setting:
The area underlain by gypsum and related anhydrite deposits is mostly confined to a flat, low-lying terrain about 40 m above sea level.

A dense, mixed forest cover of coniferous and deciduous trees supplemented with a few scattered bogs is fairly typical of the area. The size and frequency of bog areas increases east of Pink Rock Lake.

Local landscape features: In general the distribution of the region's sulphate resources east of the Shepody Bay coastal exposures is displayed through the development of a natural karstic landscape. The area is characterized by several water-filled sinkholes with Pink Rock Lake being among the largest at about 3 hectares (Figure 2).

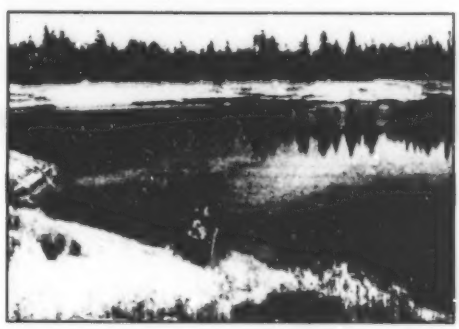


Figure 2. Pink Rock Lake is the largest karst feature on Cape Maringouin.

Karst is typically represented by an irregular surface topography characterized by closed depressions called sinkholes, caves, cave systems, stream-less valleys, disappearing streams and springs, all developed by the action of surface and underground water on

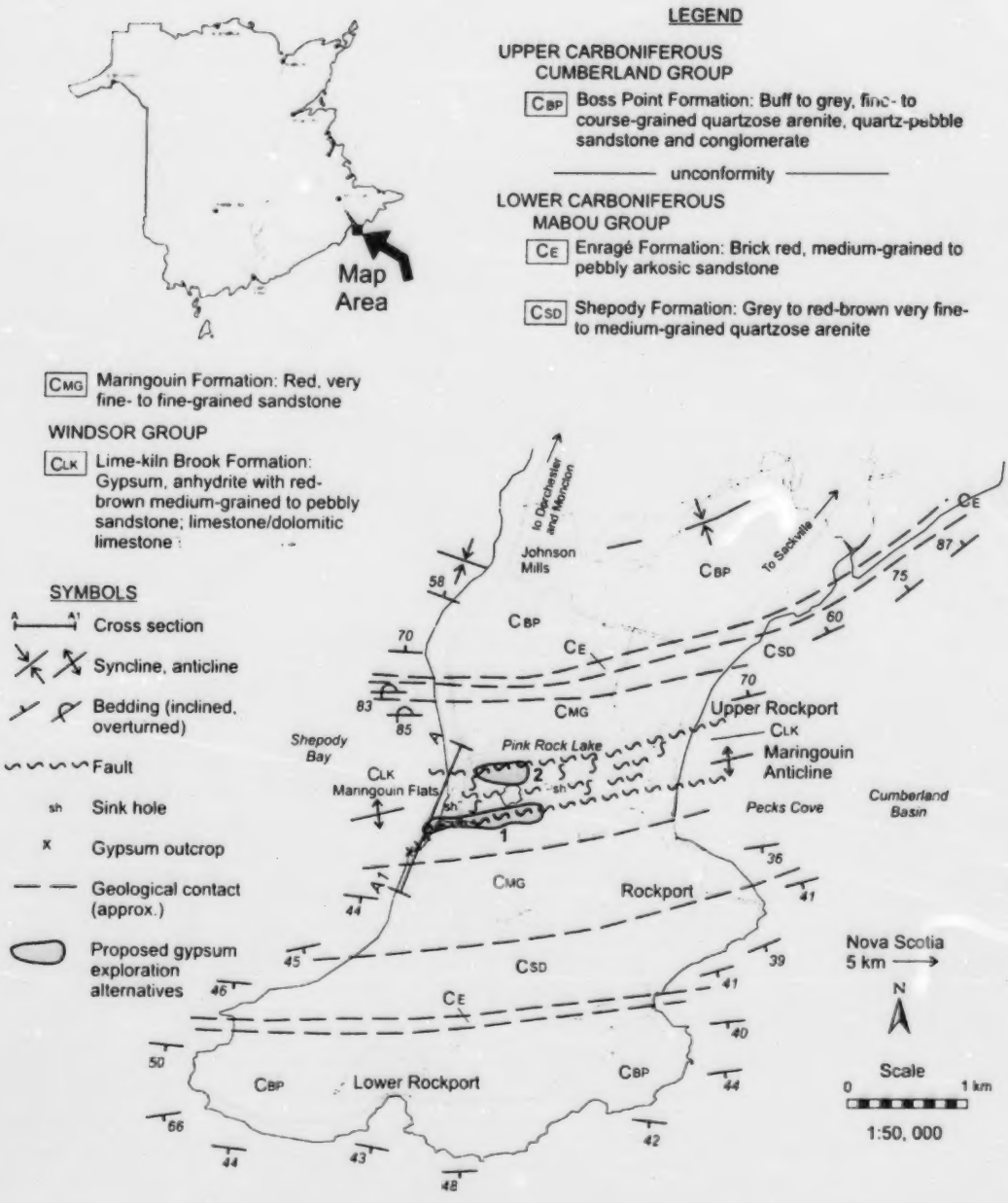


Figure 1. Location, geology and exploration alternatives for gypsum resources on Cape Maringouin Peninsula, Westmorland County, southeastern New Brunswick.

soluble rocks such as gypsum and limestone.

One of the most common landscape characteristics of the area are surface depressions developed where underlying soft gypsiferous bedrock has been dissolved and abraded by waters generally unsaturated with respect to $CaSO_4$. This often results in the formation of a network of subsurface interconnected cavities of various sizes. Eventually the surface expression of these subterranean structures appear as a sink or sinkhole, a result of structural weaknesses in overlying rock and its subsequent collapse into the cavity below forming closed depression. Surface and related ground water may drain through these sinkholes. Should the sinks subterranean plumbing system become clogged, they may fill with water, forming small lakes (*i.e.* Pink Rock Lake) and ponds, sometimes referred to as dolines or dolinas.

General land use: The remoteness and lack of easy access to the sulphate area and lands adjacent to it has limited land use in this part of the Maringouin Peninsula. Apart from the occasional visit by outdoor hiking and all-terrain vehicle enthusiasts the area is relatively undeveloped and might best be described as wilderness. No permanent housing is established within several kilometers of the area and local industrial activity in recent years (up until 2000) has been limited to a few timber-harvesting operations.

General Geology:

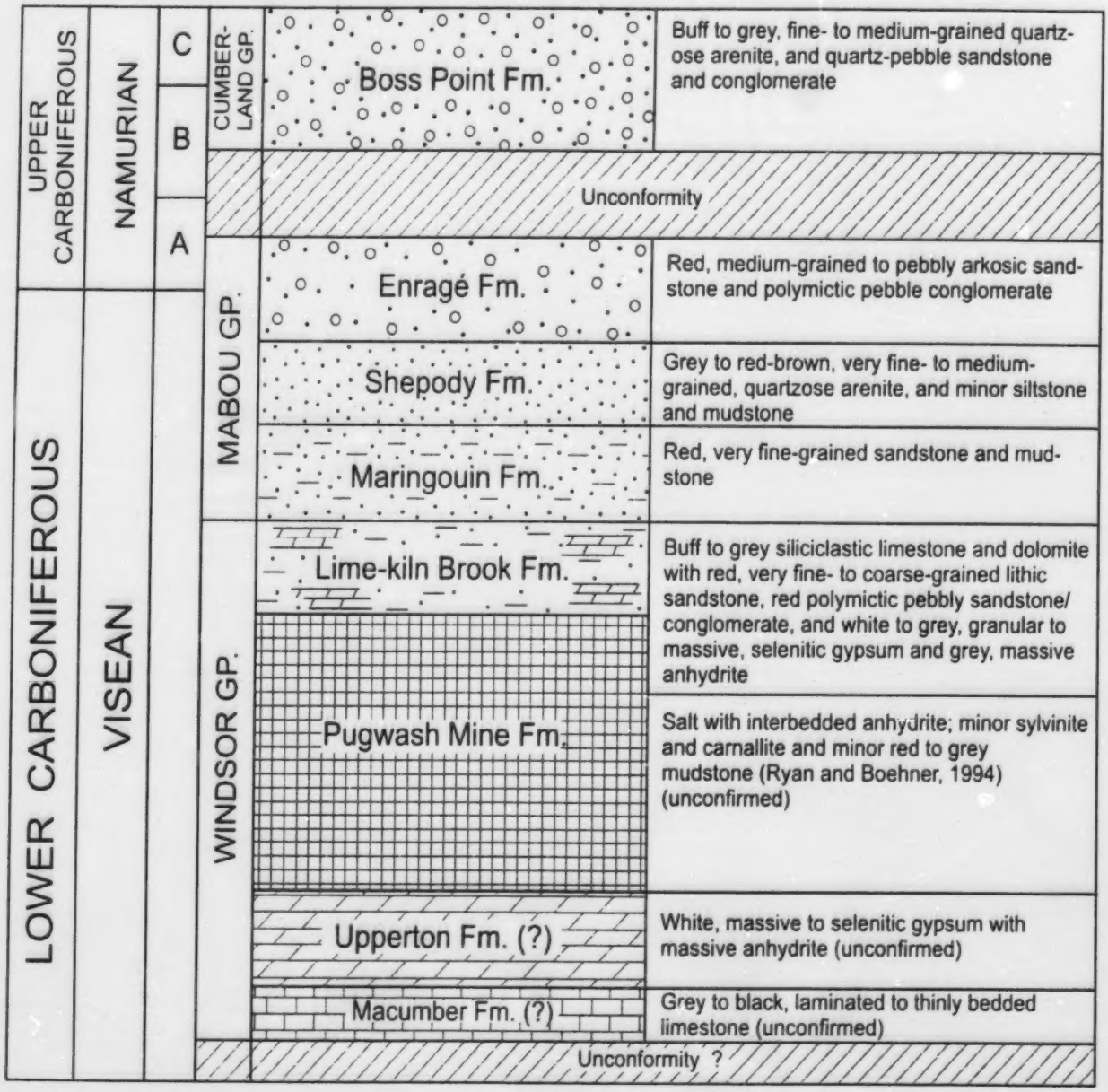
The general geology of Cape Maringouin has been presented by Norman (1941), Gussow (1953), Sund (1958), Hamilton and Barnett (1970), and most recently St. Peter (1997), St. Peter and Johnson (1997), and Johnson (1997). A summary of the region's geology is depicted in Figure 1.

The Cape Maringouin sulphate deposits occupy the crest of a major east-west-trending structural feature referred to as the Maringouin anticline near the western perimeter of the Cumberland Basin. These rocks are part of a Carboniferous assemblage of marine evaporites and continental clastic sedimentary rocks ranging in age from Visean to Namurian (Table 1).

The oldest Carboniferous rocks exposed in the area are sulphate and associated carbonates and fine-grained clastic sedimentary rocks belonging to the Lime-kiln Brook Formation of the Windsor Group. Regionally, Lime-kiln Brook strata are considered to include carbonate (*i.e.* limestone), coarse- to fine-grained clastics and sulphate units described as a ... *"white chalky gypsum with acicular crystals of selenite"* [at surface] ... *and largely ungypsified anhydrite"* [in the subsurface] ... St. Peter (1997). These rocks overlie choride (*i.e.* halite and related salt deposits) deposits of the Pugwash Mine Formation which occupy the core of the Maringouin Anticlinal structure. Although not exposed, geophysical surveys in the area indicate the presence of Pugwash strata reflected by the presence of a pronounced gravity-low ussually diagnostic of thick low density evaporites in the subsurface.

A thick sequence of fine- to coarse-grained clastics of the Mabou Group conformably overlie the Windsor Group strata (*i.e.* Lime-kiln Brook Formation) of the area. Mabou strata is represented at the base by the red, fine-to very fine-grained sandstones, siltstones and

Table 1. Table of formations for the southern half of the Cape Maringouin Peninsula, Westmorland County, southeastern New Brunswick (after St. Peter and Johnson, 1997)


LOWER CARBONIFEROUS
UPPER CARBONIFEROUS
VISEAN
NAMURIAN
C
B
A
CUMBERLAND GP.
MABOU GP.
WINDSOR GP.
Boss Point Fm.
Buff to grey, fine- to medium-grained quartzose arenite, and quartz-pebble sandstone and conglomerate
Unconformity
Enragé Fm.
Red, medium-grained to pebbly arkosic sandstone and polymictic pebble conglomerate
Shepody Fm.
Grey to red-brown, very fine- to medium-grained, quartzose arenite, and minor siltstone and mudstone
Maringouin Fm.
Red, very fine-grained sandstone and mudstone
Lime-kiln Brook Fm.
Buff to grey siliciclastic limestone and dolomite with red, very fine- to coarse-grained lithic sandstone, red polymictic pebbly sandstone/conglomerate, and white to grey, granular to massive, selenitic gypsum and grey, massive anhydrite
Pugwash Mine Fm.
Salt with interbedded anhydrite; minor sylvinite and carnallite and minor red to grey mudstone (Ryan and Boehner, 1994) (unconfirmed)
Upperton Fm. (?)
White, massive to selenitic gypsum with massive anhydrite (unconfirmed)
Macumber Fm. (?)
Grey to black, laminated to thinly bedded limestone (unconfirmed)
Unconformity ?

mudstones of the Maringouin Formation, succeeded by grey to red-brown, fine- to medium- to coarse-grained arenaceous sandstones, pebbly sandstone and conglomerates of the Shepody Formation. Brick-red, medium-grained to granular arkosic sandstone and pebble conglomerate of the Enragé Formation form the top of the Mabou strata in the area.

Mabou rocks are overlain by the Boss Point Formation of the Cumberland Group. The nature of the contact is an unconformity. These rocks are typically buff to grey, medium- to coarse-grained quartzose arenites and quartz-pebble conglomerates.

The sulphate-bearing Lime-kiln Brook rocks are best exposed on the west side of the Cape, where they can be traced almost continuously for 250 m along the shoreline adjacent Shepody Bay. North along the coast (*i.e.* the north flank of the Maringouin anticline) they are in fault contact with steeply dipping to overturned strata of the Maringouin Formation. To the south (*i.e.* the south flank of the Maringouin anticline) the contact with the overlying Maringouin clastic sedimentary rocks is conformable. The dip of the clastics (45°) in this area is geneally not as steep as those to the north.

Detailed Geology:

The geology of the southern part of Cape Maringouin and a proposed cross-section across the Maringouin Anticline is presented in Figures 1 and 3.

The coastal exposure of Lime-kiln Brook sulphate at the Cape comprises a mix of gypsum and anhydrite. Gypsum is commonly white, grey to orange-red in colour. It is generally massive but in places it displays a granular to crystalline texture displayed as thin (up to 2 cm) alternating bands of massive gypsum and selenite. Selenite also occurs as: 1) individual scattered porphyroblastic (stellate) crystals varying in size from a few millimeters to 2 cm and locally in more concentrated mineralized zones as crystal aggregates. An isolated gypsum outcrop near Pink Rock Lake, 500 meters east of the coastal exposures, is reported to contain *"selenite crystals up to several inches long"* (Hamilton and Barnett 1970).

Anhydrite, locally associated with gypsum is characterized by a grey, finely crystalline, thin-bedded material. Previous investigations in the area (Sund 1958) describe it as lenticular, residual masses enclosed by massive gypsum displaying concentric joint sets, a result of the expansive anhydrite → gypsum hydration process (*i.e.* forming anhydrite-gypsum canon-ball structures (Figure 4).

The sulphate beds are locally contorted into complex rheomorphic folds interrupted by a zone of brecciation on the south flank of the Maringouin anticline. This zone contains wedges and fragments of red mudstone and fine-grained sandstone, grey limestone, and buff colored dolomite. Regional stratigraphic correlation with similar Windsor Group lithologies a few kilometers east across the Cumberland Basin in Nova Scotia (Ryan and Boehner 1994) suggests that rock exposures on the south side of this zone of brecciation reflect a thin sequence of clastics succeeded by dolomite, a bedded gypsum (primary) unit with thin to massive selenite beds, and an arenaceous, reddish grey, algal limestone unit (Boyle 1975) overlain by fine-

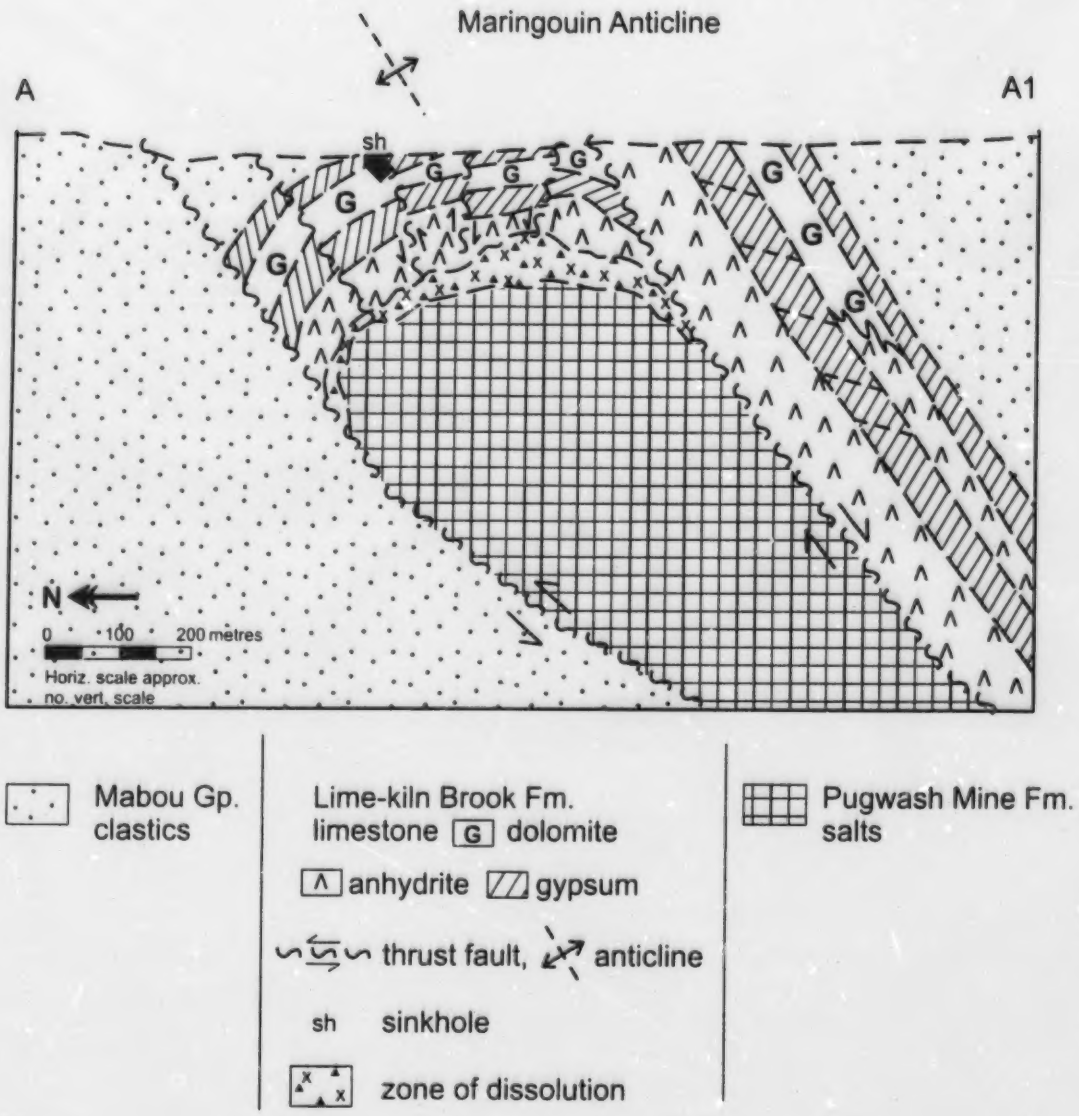


Figure 3. Schematic north-south cross-section of the Maringouin Anticline, depicting a portion of the west coastline, Cape Maringouin Peninsula, Westmorland County, southeastern New Briunswick. [no vertical scale intended and horizontal scale is approximate]

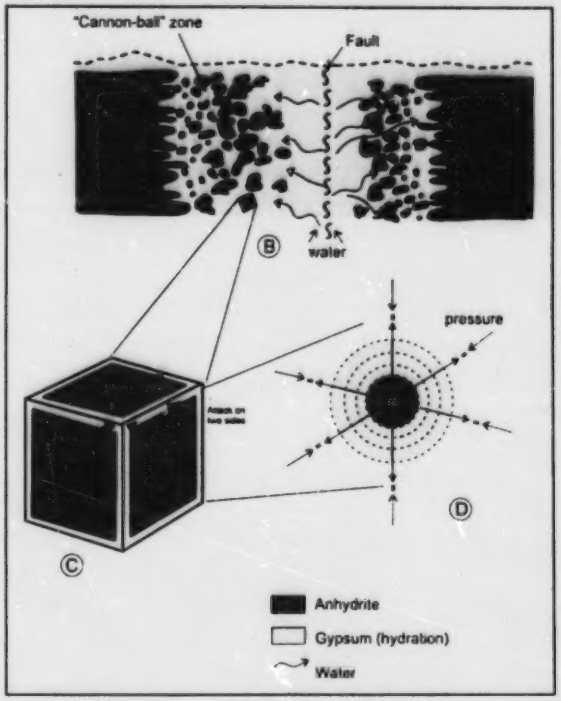
grained Mabou (Maringouin Formation) clastics. On the northern flank of the Maringouin structure only the uppermost limestone unit (Hamilton and Barnett 1970 p. 53) occurs. The underlying sulphate and dolomite beds are covered by overburden scree from an adjacent coastal cliff face.

The axial plane of the Maringouin anticline strikes northeast-southwest (075°) and dips approximately 75° south. The structure appears to plunge

Figure 4. The formation of spherical structures referred to as anhydrite-gypsum canon-balls results from the subsurface chemical weathering (hydration) of anhydrite. Concentric shells of hydrated gypsiferous rock are successively loosened and separated from a block of anhydrite by water penetrating bounding joints or fracture systems and attacking the block from all sides. These structures indicate proximity to significant fault zones and the outer limit of active hydration fronts.

The formation of anhydrite/gypsum "canon-ball" structures (A)is analogous to a form of exfoliation. This process involving the formation and separation of successive concentric layers of hydrated (gypsiferous) material around an anhydrite core frequently occurs in rock cut by intersecting joints and fracture systems adjacent fault structures. Joints and fractures provide avenues where the slow movement of water can attack separate fractured- or joint-bound blocks of anhydrite from all sides (B). The moisture that penetrates between fragmented masses of anhydrite remains long enough for hydration and the subsequent formation of gypsum. As the depth of hydration is greater at corners and edges than along flat surfaces (C), a spherical-shaped shell of gypsum is formed (D). Hydration is accompanied by an increase in rock volume. This sets up forces within the rock that cause gypsiferous layers to separate from the main anhydrite mass. A fresh hydration surface is established and the gypsification (anhydrite hydration) process is repeated again and again until an equilibrium in pressure is established between the inner hydrating anhydrite core and the perimeter of the "canon-ball" structure.

Each successive wrapping surrounding the anhydrite becomes more spheroidal than its outer neighbor, until the original anhydrite block is transformed into an onion-like structure of concentric shells of residual gypsiferous material (D).



to the east under the Cumberland Basin and is characterized by both gravimetric (Hassan 2000 and Williams 1978) and structural assymetry. Mabou clastic strata on it's northern limb varies from steeply dipping to locally over-turned while that on the southern limb dips at about 45°. Similarly a steep versus a more uniform gravity gradient is apparent in the north and south limbs, respectively. It is suggested that the Maringouin anticline is a salt piercement structure involving less dense rocks (*i.e.*

salt) moving upward through more dense strata. As the salt mass displaces the overlying and adjacent strata upward and outward marginal thrust faults develop. At Maringouin this type movement is reflected in the asymmetrical nature of the anticlinal structure and the contorted and fragmented nature of bedding[1] developed in strata overlying the salt mass. The spatial distribution of these subsidiary fault structures tend to reflect the narrow and elongated, northeast trend of the underlying salt mass Because cover rocks must also accommodate extension associated with uplift, and respond to the dissolution of the underlying salt body, a series of normal faults have developed locally over the top of the structure (Figures 1 and 3).

Various structural adjustments (*i.e.* subsidiary thrust faults and normal faults) associated with the formation of the Maringouin Anticline has provided an important control on the development and distribution of the gypsum resources in the area. It is suggested that fault structures most likely served as conduits for the upward movement of subsurface waters which:

1. hydrated (gypsified) anhydrite overlying and adjacent to more soluable evaporites (*i.e.* halite);

2. caused dissolution of evaporites (*i.e.* salt) and the subsequent collapse of overlying and adjacent strata and

3. periodic recrystallization of gypsum (*i.e.* formation of selenite veins, crystals etc.)

Deposit Type:

Calcium sulphate is typically the product of chemical precipitation from saturated brines resulting from evaporation at the air-water interface in marine basinal and related environmental settings. It is suggested that calcium sulphate in the Maringouin area reflect two depositional settings: (1) Sulphate crystals generated at the air-water interface, gradually settling on the sea floor, forming primary bedded selenitic gypsum and massive bed of crystal aggregates on a shallow-water, marine platform and (2) in the form of thick sequences of laminar anhydrite in a deep-water, marine basin setting (Figure 5). Deeper water environments would have been characterized by elevated salinity and temperature - a setting where a primary calcium sulphate in the form of gypsum is not stable resulting in its alteration to the more stable mineral form, anhydrite.

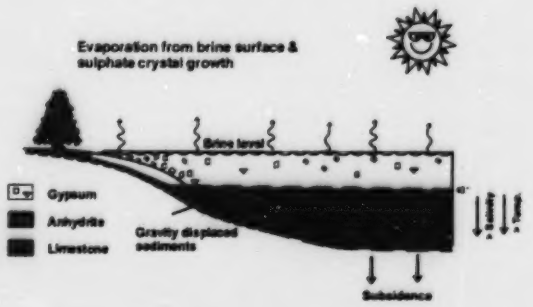


Figure 5. Typical depositional setting for primary calcium sulphate depsosits

It appears that apart from the primary gypsum some of the region's gypsum resource is the hydration product of anhydrite (*i.e.* absorption of water

[1] The distortion and fragmentation of bedding is a considered a function not only of the intrusive upward movement of salt but also a response to the underlying dissolution salt and subsequent collapse of overly strata.

molecules into the anhydrite mineral structure). Faulted terrain and related fracture systems have had a direct impact on the effectiveness of the hydration process and the complex spatial relationship between gypsum and anhydrite (Figure 6). Water-bearing fault zones serve as suitable hydration sites for the alteration of adjacent anhydrite deposits resulting in narrow linear zones and veins of massive to recrystallized high-grade gypsum, gradational into a hetrogeneous zone of anhydrite and gypsum [and eventually massive anhydrite at some distance from the active hydration front (Figure 6).

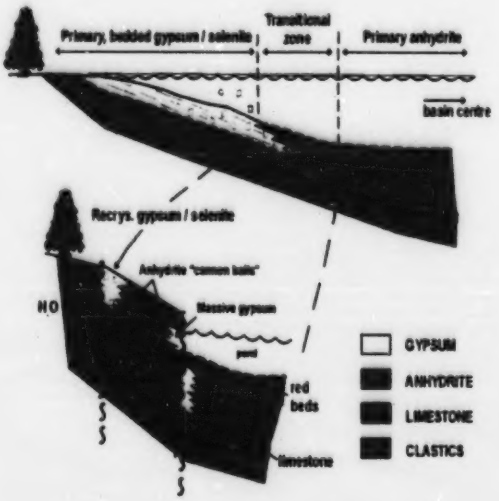


Figure 6. Formation of some gypsum deposits in the Maringouin area may be directly linked to active hydration fronts developed adjacent faults and related fracture zones. Anhydrite" canon balls" generally mark the outer limit of individual hydration zones.

Exploration and Development History:

One of the earliest references to gypsum deposits at Cape Maringouin appears in notes kept by W. E. Logan[2] during a 1843 visit to the Bay of Fundy region.

The tidewater location of the occurrence and the demand for "crude rock" [3] gypsum in the United States appear to have stimulated early development interests in the resource. Early correspondence around the turn of the century makes mention of some mining activity on the property prior to 1877. Sometime between 1877 and 1884 the property referred (Friel *c.*1904) to as that situated *"at Hard Ledge on Rockport"* was purchased by a Captain David E. Taylor. It is reported (Friel *c.*1904) that Taylor along with a partner established a gypsum operation there although no details were provided as to the nature or the longevity of the enterprise. Following the death of his partner, Taylor apparently curtailed operations and moved to New York where he was successful in assembling investment interests and established a plaster manufacturing facility. Taylor's company looked northward to the Cape Maringouin area as one potential source of gypsum for the New York plant. However, he was soon informed by government officials that his licence to search (mineral rights) for the property had expired in 1903 and the other parties from the Dorchester and Moncton area

[2] Sir William Edmond Logan (1798-1875): One of the foremost Canadian geologists of the 19th century and founding director of the Geological Survey of Canada. Through his many published reports, maps and exhibits he played a key role in recognizing the nation's mineral potential. In 1843 he conducted geological investigations related to coal deposits in New Brunswick and Nova Scotia.

[3] crushed gypsum

had subsequently taken out a new license. Taylor's plans to employ 200 men at the Maringouin site apparently did not come to pass as did plans to further develop the property by other local residents.

It seems that a 1905 letter to the Crown Lands Department makes mention of yet another gypsum quarry in the Cape Maringouin area. This operation, at Pink Ledge, about a mile north of the end of Cape Maringouin on the east side of Shepody Bay (Ells 1907) was situated on a one square mile parcel land leased (Lease 50) to a Mr. Herbert W. Ladd in 1901 (Carroll 1980). Ells (1907) described the deposit as one of *"large size and excellent quality from which shipments have already been made"*. Although Ladd and a collection of associates attempted to develop the property themselves it was not until 1905-1906 and the involvement of C.J. Osman, business manager of the Albert Manufacturing Company that operations began in earnest.

Operating under the name of the New Brunswick Gypsum Company Ltd., [a subsidiary of the Albert Manufacturing Company (AMC), active in the gypsum industry a few kilometres across Shepody Bay at Hillsborough], Osman and associates [Calvin and Walter Tomkins (NY); Rutledge Odell (NY) and Fred Thompson (Hillsborough N.B.)] not only purchased the Ladd lease but also acquired the "Taylor" property as well (Osman 1905 and Annual reports of the Crown Lands Department 1906 pp. 55).

In 1906, a substantial wharf[4] was constructed adjacent the Pink Rock property (see frontispiece). It is reported that two thousand tons of gypsum was mined (Annual reports of the Crown Land Department 1907, p.xxix). Development activity on the property appears to have been somewhat sporadic with reports of several thousand tons extracted between 1907 and 1914, most being shipped in the crude form to the United States-based plaster mills (Annual reports of the Crown Land Department 1908, p. xxv; 1912, p.xxxiii; 1913, xxi; and 1914, xvii; Jennison 1911, p.96; Cole 1913, p.46). The New Brunswick Gypsum Company apparently had big plans for the Pink Rock site proposing to do considerable work there. It seems the demand for "crude rock" gypsum exports into the US was continually increasing but the parent company, AMC was reluctant to address the supply challenge singularly from their Hillsborough resources across the bay (Annual report of the Crown Land Department 1919, p. 66). The North American demand for plaster, manufactured at Hillsborough, was also increasing rapidly. In light of this development the company set out to restrict or conserve its Hillsborough gypsum deposits for that purpose.

About 1200 tons of material was quarried from the Pink Rock lease in 1920. The company would have continued operations there but unfortunately its main market, plaster mill(s) near New Haven, Connecticut were suddenly destroyed by fire (Annual report of the Crown Lands Department 1920, p.96). As a result the Pink Rock quarry operation was immediately

[4] The ruins of the former wharf are barely visible at low tide.

suspended with several hundred tons of accumulated rock left on the wharf. Although the mills scheduled to use this rock were rebuilt in 1921, regular shipments from the Pink Rock lease apparently did not resume. Records indicate that the Pink Rock operation was not extended past 1921 (Annual report of the Crown Lands Department 1921, p. 51). Although mentioned in several publications (Goodwin 1928, p.50 ; Thomas 1930, p.94; Cole 1930 ; Sund 1958, pp.86-94; and Hamilton and Barnett 1970, p.51) since that time, there has been no record of production or renewed activity on the Pink Rock (Cape Maringouin) property. Today the remnants of the old workings near the coast along with the ruins of the adjacent wharf provide a distant reminder of its former gypsum enterprise(s).

Preliminary Deposit Evaluation:

The Cape Maringouin gypsum deposits are restricted to the central axis of the Maringouin anticline. The axial plane of this structure trends east-west, dips to the south and plunges to the northeast across the Maringouin Peninsula, under Cumberland Basin. Two sulphate units are exposed on the west-side of the Cape:

1. an upper even-bedded gypsiferous unit, probably only a few meters thick, and ...

2. a lower, massive to bedded gypsum with local anhydrite-cored spheroids.

These units are characterized by a convoluted style of bedding, with fragments of clastics, limestone and dolomite incorporated into a gypsum matrix. The thickness of this unit is not known but comparisons with deposits in similar stratigraphic and structural settings throughout the region (*i.e.* Dorchester salt plug at Dorchester, New Brunswick, several kilometers to the north and the Minudie Anticline near Lower Maccan, Nova Scotia) suggest it may be in the order of tens of meters.

The occurrence of gypsum is considered structurally linked to prominent east-west trending faults that assist in defining the northern and southern limit (Figure 5) of the Maringouin Anticline. The surface expression of these faults is indicated by a karst terrain (*i.e.* line of sinkholes) developed in the west-central to north half of the structure. The karstic area is traceable eastward from coastal gypsum exposures for about 1000 m. Further to the east, towards Cumberland Basin, there is no surficial indications of gypsum in the subsurface (*i.e.* no sinkholes, no outcrop etc.). This is may be related to normal faulting to accommodate extension associated with the upward (diapiric) movement of underlying Windsor Group evaporites. Local structural adjustments of this nature might account apparent eastward plunge of the Maringouin Anticline, resulting in a greater depth to and protection of major sulphate units by overlying clastic and carbonate cover rocks.

It appears that the best exploration alternative for gypsum in the Cape area is restricted to west half of the peninsula, along the projected northern and southern flanks of the Maringouin Anticline. These potential gypsum resource areas are accessible via an all-terrain vehicle trail extending 3 to 4 km south of its intersection with Highway Rte. # 935 near Johnson's Mills. The

trail, which skirts the western coastline of Shepody Bay leads to several exposures of gypsum on the shore and ends at a cut-over, 400 m further south. Limited analytical data from these rocks has yielded gypsum, generally below 80 % [Appendix A; (Hamilton and Barnett 1970; Cole 1930)]. In addition, the extent to which overlying and underlying non-sulphate strata are incorporated into parts of the deposit would require careful consideration.

Access to a proposed extension of these coastal deposits near Pink Rock Lake, 700 meters to the east, is achieved by another narrow ATV trail. Gypsum in the lake area is limited to a few isolated exposures. Although no quality data is available, visual examination indicates similarities with gypsiferous material on the coast.

Considering the general low relief and shallow water table in the Pink Rock Lake area there remain two slightly elevated sites near the lake that may be worthy of more detailed efforts to test the presence and nature gypsum resources.

Gypsum Area 1, is moderately elevated area, covering about 100 hectares, extending south of Pink Rock Lake and west to the Maringouin Flats on Shepody Bay (Figure 1). This potential resource area follows the general trend of a proposed east-west trending fault structure on the southern limb of the Maringouin Anticline that may have served as a hydration front in adjacent anhydrite deposits. Unfortunately a major portion of the site is not readily accessible.

Another area, Gypsum Area 2, comprises a 50-hectare site of slightly lower relief than Gypsum Area 1. Situated just north of the lake (Figure 1) it is also influenced by another fault structure marking the northern boundary of the anticline. It can be accessed by a trail leading to the Pink Rock Lake. This trail connects eventually with the coastal Shepody Bay trail to the west.

The true nature of the gypsum resource in these areas is a matter of speculation at this point with many questions remaining as to its quality and consistency, overburden thickness, ground conditions and other related development issues.

In consideration of the extent, quality and consistency of the gypsum resources at the Cape, it is interesting to note that similar deposits associated with Lime-kiln Brook strata are found 25 to 30 km along strike in northern Nova Scotia. Gypsum has been quarried at Amherst Point (1912-13) and near Nappan (1959-62), although these operations were short-lived, lasting for only a few years. The Nappan deposit was apparently hindered by quality control problems *"related to ...extensive infiltration of [clastics] into a complex karst system of fractures and cavities"* (Ryan and Boehner 1994).

Conclusions:

Near surface deposits of gypsum and anhydrite are known to extend over 120 hectares on the central-west half of the Cape Maringouin Peninsula at the southernmost tip of Westmorland County, southeastern New Brunswick. Gypsum and anhydrite, exposed 300 to 400 m along the Shepody Bay coastline

can be traced several hundred meters eastward via a series of water-filled sinkholes and limited outcrop.

The sulphate rocks in the area belong to a Lower Carboniferous, Windsor Group sequence of marine carbonates, and evaporites interstratified with nonmarine clastics referred to as the Lime-kiln Brook Formation. The local spatial distribution of the formation and its gypsiferous deposits is related to the region's structural development (*i.e.* northeast-southwest-trending, peripheral thrust faults and north-south normal faults) associated with the subsequent development of a salt-cored piercement structure, the Maringouin Anticline.

Recent reconnaissance work in the area suggests the probability of at least two separate sulphate units associated with Lime-kiln Brook strata. The lowest-most sulphate unit consists of white to pinkish, bedded to massive gypsum (secondary) with variable amounts of ungypsified anhydrite (anhydrite /gypsum "canon-balls") and scattered selenite crystals. The thickness of this unit is undetermined although it appears to account for a major part of the coastal exposure. Structurally these rocks are found near the axial part of the Maringouin Anticline. As a result they have undergone considerable deformation. Fragmented (breccia) clastics, and carbonates are locally, incorporated into the sulphate strata. This zone of brecciation is considered the product of fault movement along the southern flank of the Maringouin anticlinal structure related in part to the upward movement and subsequent dissolution of underlying evaporites (*i.e.* salt). This deformation can affect the quality and consistency of the gypsiferous material locally.
A thin unit of dolomitic limestone separates the lower (anhydrite/ gypsum) sulphate unit from an overlying gypsum unit. Several meters thick, this unit consists of even-bedded gypsum and selenite and an abundance of selenite crystals scattered throughout a gypsum matrix or occurring as more massive crystalline beds locally. This upper sulphate is capped by a thin layer of arenaceous, algal limestone. The nature of selenite mineralization and bedding style suggests a primary origin for this upper sulphate unit.

Quality control of the Cape Maringouin gypsum is limited to only a few samples with gypsum contents in the mid 70 to low 80 % range (Appendix A). The effects of deformation on the spatial distribution of gypsiferous material and the potential for brecciation and subsequent contamination by interstratified clastics and carbonates are likely to affect the quality and consistency of the resource. It is worth noting that similar deposits of Lime-kiln Brook gypsum in nearby northern Nova Scotia have a history of exploration and limited production. However, it appears that most operations were relatively short-lived, plagued by quality control problems.

Cape Maringouin gypsum has a sketchy production history going back to the 1870's. The most prominent and prolonged period of mining activity began in the early 1900's continuing for almost 20 years. Over this period small cargoes of "crude rock" were exported by boat to plaster mills along the northeastern seaboard of the United States.

In consideration of social impacts and related development concerns affecting the gypsum resource it is to be noted that the area is relatively remote from housing and other potentially competing land uses. With the possibility for land use conflict minimized and the fact that the deposit is traceable over a considerable area (1.5 to 2 km inland from the coastline exposures adjacent Shepody Bay), the Maringouin prospect has appeal as an exploration and potential development alternative. Although most of the deposit occupies a flat, low-lying, swampy terrain there remain two areas of higher relief in the vicinity of Pink Rock Lake that may be worthy evaluation. The presence and quantitative/qualitative details of the resource remain untested. Given the limited exposure of gypsum in both areas an appropriate drilling program would be required to establish an informed opinion of its extent and concerns related to quality control.

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APPENDIX A

Compiled chemical analysis of gypsum samples (outcrop) from the west coast line of Cape Maringouin, Westmorland County, southeastern New Brunswick (1930-1970)

Appendix A : Compiled chemical analyses of gypsum samples (outcrop) from the west coastline of Cape Maringuoin, Westmorland County, southeastern New Brunswick *(c – calculated).*

Source	Insol.	Fe_2O_3	SiO_2	Al_2O_3	CaO	MgO	SO_4	H_2O	Total	$CaSO_4 \cdot 2H_2O$	$CaSO_4$
Cole (1930)	0.64	0.14	-	-	33.85	0.21	47.78	16.63	99.25	79.47	18.79
Hamilton and Barnett (1970)	-	0.12	1.07	0.57	31.84	0.76	44.56 (SO_3)	19.30	98.15	72.65[c]	3.09[c]